Resource Inventory Notes

BLM 14 October 1978

MODIFICATION OF FREESE'S CHI-SQUARE TEST OF ACCURACY

by

John C. Rennie and Harry V. Wiant, Jr.[1/]

ABSTRACT: A Chi-square test of accuracy has been modified to be of more general application. The interpretation of the statistic is given.

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Evaluation of accuracy for new instruments and techniques is an ongoing effort. Until recently, a paired t-test was used to compare a new procedure with the accepted procedure or actual values. To overcome problems introduced into this test by involving two forms of variation, Freese (1960) proposed a test using Chi-square to determine if a new procedure had desired accuracy. As presented, this test works well for the user who knows the desired level of accuracy. However, as Brickell (1976) points out, the need of a specified goal of accuracy reduces the usefulness of the original form of Freese's Chi-square test of accuracy because one user's goal may be too accurate or not accurate enough for other users.

By modifying Freese's test, which is hypothesis testing, to an approach of confidence limits, the authors have provided a test which is more useful for presenting results in the literature (Wiant and Koch, 1974; Boehmer and Rennie, 1976). With this modification, research results are given as error limits; the reader can then decide whether to use the new instrument or measurement procedure for a particular application by comparing the error limits with the accuracy he needs.

Modification: Freese (1960) compared a value of Chi-square calculated using equation 1 with a tabular value to decide if a new procedure had at least the desired level of accuracy unless the sample was rare (probability of α_1). To express research results in terms of accuracy, equation 2 was substituted into equation 1 and solved for the error limit, E, as shown in equation 3. The error limit as a percent of the true value can be calculated with equation 4.

1/ The authors are, respectively, Associate Professor, Department of Forestry, Wildlife, and Fisheries, the University of Tennessee, Knoxville, 37916, and Professor, Division of Forestry, West Virginia University, Morgantown, 26506.

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Interpretation: Using equation 3 and the data presented in Table 1 of Freese (1960), an error limit of 21.24 is obtained with α_1 = 5% and α_2 = 5%. From this it can be said that 95 percent of the deviations between the values from the new procedure and the values from the standard will be less than or equal to 21.24 unless the data constitutes a rare sample (5% probability). Using equation 4, we expect 95 percent of the deviations to be within ± 4.8%.

The proportion of deviations expected to be included by the error limits is determined by the probability α_2 associated with the standard normal deviate. The probability of encountering a rare sample is incorporated through the probability α_1 associated with the value of Chi-square used to calculate the error limit.

Literature Cited

Boehmer, W.D. and J.C. Rennie. 1976. Predicting diameter inside bark for some hardwoods in West Tennessee. Wood Science 8(4): 209-212.

Brickell, J.E. 1976. Bias and precision of the Barr and Stroud dendrometer under field conditions. USDA Forest Service Research Paper INT-186.

Freese, F. 1960. Testing accuracy. Forest Science 6(2): 139-145.

Wiant, H.V., Jr. and C.B. Koch. 1974. Predicting diameters inside bark for outside bark measurements on some Appalachian hardwoods. J. Forestry 72(12): 775.

$$\chi^2(n,\alpha_1) = \frac{\sum_{i=1}^{n} (x_i - \mu_i)^2}{\sigma^2} \qquad (1)$$

where χ^2 is the calculated value of Chi-square with n degrees of freedom and probability α_1.

X_i is the value of the ith individual by the new procedure.

μ_i is the value of the ith individual by the accepted procedure.

σ^2 is the hypothesized variance.

$$\sigma^2 = E^2 / z^2 \qquad (2)$$

where E is the error limit which includes $(1 - \alpha_2)$ of the deviations between X_i and μ_i.

z is the standard normal deviate for probability of (α_2)

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$$E = \left\{ \frac{[Z^2]\left[\sum_{i=1}^{n} (x_i - \mu_i)^2\right]}{\chi^2_{(n,\alpha_1)}} \right\}^{\frac{1}{2}} \qquad (3)$$

$$E = (\%) = \left\{ \frac{[Z^2]\left[\sum_{i=1}^{n} \left(\frac{x_i}{\mu_i} - 1\right)^2\right]}{\chi^2_{(n,\alpha_1)}} \right\}^{\frac{1}{2}} (100) \qquad (4)$$

where E (%) is the error limit as a percent of the true value μ

Examples: Using equation 3 and the data in Table 1,

$$E = \left\{ \frac{(1.96)^2\ (2150)}{18.31} \right\}^{\frac{1}{2}} = 21.24$$

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Using equation 4 and the data in Table 1,

$$E = (\%) = \left\{ \frac{(1.96)^2\ (.01092)}{18.31} \right\}^{\frac{1}{2}} (100) = 4.8$$

Table 1: Comparison of results from new measurement method (X_i) with accepted method (μ_i). (Adapted from Freese, 1960)

Observation No.	X_i	μ_i	$(X_i - \mu_i)^2$	$(\frac{X_i}{\mu_i} - 1)^2$
1	495	500	25	.00010
2	360	380	400	.00277
3	480	480	0	.00000
4	280	290	100	.00119
5	610	600	100	.00028
6	505	540	1225	.00420
7	320	320	0	.00000
8	390	400	100	.00063
9	350	360	100	.00077
10	310	320	100	.00098
			$\Sigma = 2150$	$\Sigma = .01092$

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A SHORTCUT FOR THE DEVELOPMENT OF WEIGHT YIELD TABLES

by

Harry V. Wiant, Jr.

ABSTRACT: Weight yield tables for evenaged upland oak forests were derived using recently developed weight equations and stand tables published in 1937 by G. L. Schnur. A similar approach is feasible in other forest areas.

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The utility of weight as a unit of measure in forestry has long been recognized, and interest has been stimulated by the introduction of whole-tree chipping operations. Weight tables have been developed for many species, and a summary of much of this work was recently presented by Young (1976). Using previously prepared weight equations, Wiant and Castaneda 1/ developed weight yield tables for evenaged upland oak forests. The procedure used makes use of previously published conventional yield tables and should prove useful in other forest areas.

Procedure

Single-entry weight equations and tables using dbh were developed recently for several Appalachian hardwoods in northern West Virginia for several Appalachian hardwoods in northern West Virginia (Wiant et al. 1977). The next logical step was the development of weight yield tables, facilitated by using stand tables published by Schnur (1937).

Schnur's tables give the number of trees by diameter classes for 10-year intervals between 10 and 100 years and for 10-foot site index classes between 40 and 80. The number of trees in each cell is given by species group: white oaks, black oaks, other intolerant, and other tolerant.

Weight equations were developed in West Virginia for the white oak group and the red or black oak group. An examination of the species classed as "other tolerant species" indicated the equation for red maple might suffice, and for the "other intolerant class" an average of hickory and yellow-poplar values seemed appropriate. Multiplication of the proper equation by the number of trees provided per-acre weight yields.

Results

Green and dry weight yields were calculated for whole trees, excluding stumps, roots, and leaves. Tables developed for trees 5 inches dbh and above and for material 4 inches dob or less provide for interesting comparisons of conventional pulpwood operations and whole-tree chipping. Examples of the tables produced are shown in tables 1 to 3. Table 3

The Author - Harry V. Wiant, Jr. is professor of forestry, Division of Forestry, West Virginia University, Morgantown. WVU Agri. and Forest. Exp. Stn. Sci. Paper 1531.

1/ H.V. Wiant, Jr., and F. Casteneda. Preliminary weight yield tables for evenaged upland oak forests. (in press)

indicates that the increase in yield of wood from whole-tree chipping as compared to conventional operations is never less than 25 percent and may be much higher.

Weight yield tables are needed in many areas, and the procedure used here is feasible if adequate stand tables have been developed in previous studies.

Table 1. Yield per acre of dry weight, excluding bark, stumps, roots, and leaves, for upland oak forests (lbs.).

Total age (years)	Site Index 40	50	60	70	80
10	11960	12549	16009	17393	18833
20	23169	30865	33555	40048	52378
30	38407	49933	58478	69886	75859
40	51524	62509	73554	84464	93995
50	61131	73431	91342	103879	120547
60	71883	84565	104141	118992	129888
70	76664	93186	111665	125177	136937
80	84348	106960	119155	136558	143149
90	94810	114575	128605	143792	148780
100	102422	121904	133896	149772	158230

Table 2. Yield per acre of dry weight, excluding bark, stumps, roots, and leaves, for trees 5-inches dbh or more to a 4-inch dob in upland oak forests (lbs.).

Total age (years)	Site Index 40	50	60	70	80
10	0	0	0	0	0
20	0	2159	4232	9787	22114
30	8786	19985	31253	45141	53271
40	24965	38137	50879	62126	70580
50	36890	50513	67714	78007	90168
60	48891	61982	78348	89202	96150
70	55007	69693	84051	93022	99974
80	61986	80585	88875	100439	103898
90	71092	85925	95911	105117	106097
100	76864	91547	99247	108510	111863

Table 3. Percent of yield of wood in material 4-inches dob or less in upland oak forests.

Total age (years)	Site Index 40	50	60	70	80
10	100	100	100	100	100
20	100	93	87	76	58
30	77	60	47	35	30
40	52	39	31	26	25
50	40	31	26	25	25
60	32	27	25	25	26
70	28	25	25	26	27
80	27	25	25	26	27
90	25	25	25	27	29
100	25	25	26	28	29

Note: Obtained by dividing the difference in Table 1 and Table 2 values by Table 1 values (x 100).

Literature Cited

Schnur, G.L. 1937. Yield, stand, and volume tables for even-aged upland oak forests. USDA Tech. Bul. 560.

Wiant, H.V., Jr., C.E. Sheetz, A. Colaninno, J.C. DeMoss, and F. Castaneda. 1977. Tables and procedures for estimating weights of some Appalachian hardwoods. W.Va. Univ. Agri. & Forest. Exp. Stn. Bul. 659T.

Young, H.E. 1976. A summary and analysis of weight table studies. Complete Tree Institute, Univ. of Main, Orono.

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Letters

Mr. R.B. Chevrou, Office National des forets, Place Freycinet, 09007 Foix, France ask that we place his following letter in the "Notes".

Dear Sir,

In your Resource Inventory Notes BLM 12 of July 1978, M. Zohrer has exposed a new formula to compute the precision of dot grid estimates = "On the precision of dot grid estimates " by F. Zohrer.

Please, find enclosed my last paper* on the subject where you will read my new formula which can be written as follows:

log S% = 1.700 -0.75 log n + 0.5 log p, [1/] as compared to Zohrer's one, that is:

log S% = 1.739 -0.755 log n + 0.457 log p

The coefficients of log n (-0.75) and of log p (0.5) in my formula are certainly correct as corresponding with what one can expect from a theoretical point of view.

The difference between these formulaes are very small (0 to 3%) in the useful range.

Thank you.

Truly yours,

R.B. Chevrou
June 24, 1978

1/ or S% = 50 n -0.75 p 0.5

* Chevrou, R.B. 1976 Precisions des Mesures de Superficie Estimee par Grille de points ou intersections de Paralleles. Ann. Sci. forest 33(4):257-269. (An English summary)

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Current Literature

Please order directly from sources given.

General

The Newsletter of the Canada committee on Ecological (Bio-Physical) Land Classification (CCELC) is available from the Lands Directorate, Dept. of Fisheries and Environment, Ottawa, Ontario K1A 0E7. This Newsletter carries several interesting articles and announcements.

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Res. Report PSW - 25 "Simulating Forest Pictures by Impact Printers" and Reprint "Computer Mapping Systems for Integrated Resource Inventories" by Elliot Amidon are available from the Pacific Southwest Forest and Range Exp. Station, P.O. Box 245, Berkeley, CA 94701.

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Technical Paper 280 "A Strategy For Selecting a Worth Assessment Technique".

Technical Paper 284 "Factors in Design of Hardcopy Topographic Maps" both from US Army Res. Inst. for Behavorial and Social Sciences, 5001 Eisenhower Ave., Alexandria, VA 22333.

FORESTRY

DNR Report No. 37 "A Profile of Western Washington's Nonindustrial Forest Landowners" from State of Washington, Dept. of Natural Resources, Olympia, WA 98504.

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Circular 476 "Check Your Timber Sales" and Circular 614 "Tax Savings on Timber Sales" available from Cooperative Extension Service, University of Georgia, Athens, GA 30601.

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Gen. Tech. Report. NC-20 "Estimating Aspen Volume and Weight for Individual Trees, Diameter Classes or Entire Stands".

Res. Paper NC-149 "Predicting Oak Stump Sprouting and Sprout Development in the Missouri Ozarks".

Res. Paper NC-144 "Secondary Wood Residue" Production, Use and Potential in the Twin City Area".

Res. Paper NC-129 "A Computer Simulation of Full-Tree Field Chipping and Trucking".

From North Central Forest Exp. Station, Folwell Ave., St. Paul, MN 55108.

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Proceedings of the IUFRO Meeting on "National Forest Inventory" held in Bucharest, Romania are now available. These proceedings represent an excellent survey of what is presently done worldwide in the area of National Forest Inventory. Nearly 90 papers - most in English are contained in the document. For price and availability, please contact:

Ing. G. Bumbu, Director
Institutul de Cercetari si Amenjeri Silvice
sos Stefanesti NR. 128
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A limited number of copies of "Yield, Growth and Site - A Bibliography For Eastern Forest Species Excluding the Southern Pines" by H. Gyde Lund is available from our office. Drop us a line for a copy.

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Res. Paper 88 "The Advantages of a Plantation Investment for the Georgia Timberland Owner" from Georgia Forestry Commission, P.O. Box 819, Macon, GA 31202.

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Pamphlet "How to Identify and Control Non-infectious Disease of Trees". from North Central Forest Experiment Station, 1992 Folwell Ave., St. Paul, MN 55108.

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"Illinois Forest Inventory Data Processing System Program Documentation", by Dieter R. Pelz. Staff Paper No. 78-1, available from Department of Forestry, University of Illinois, Urbana, IL 61801.

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"Count Sampling in Forestry" by Hans Schreuder in Forest Science Vol. 24, No. 2 p. 267-272. June 1978. At your local conservation library.

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RANGE & WILDLIFE

Extension Circulars 942 "What to Look For in Evaluating Hay" and 943 "Forage Quality - What It Is and Why It Is Important" from Extension Service, Oregon State University, Corvallis, OR 97331.

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Res. Note NC-226 "Biomass Estimation For Some Shrubs For Northern Minnesota".

Res. Paper NC-147 "A Survey of Fishes of the McCormick Forest" both from North Central Forest Exp. Station, Folwell Ave., St. Paul, MN 55108.

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Pub. VPI-FWS-4-75 "Recreational Fisheries Management and Ecosystem Modeling" by Lackey from Dept. of Fisheries & Wildlife Sciences, VPI & State University, Blacksburg, VA 24061.

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Meetings

SAF National Convention. October 22-26, St. Louis, MO. Contact SAF, 5400 Grosvenor Lane, Washington, D.C. 20014. The SAF Inventory, Biometrics and Remote Sensing Working Groups with corresponding Canadian groups will be holding a joint technical meeting on "Measurements: Gateway to Knowledge" at the convention. Plan now to attend - the time will be 1:00 p.m. on October 24th. A working group business meeting will follow. Problems on Urban Forest Inventory will be discussed on October 26th.

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Forest Growth and Yield Workshop. Sponsored by the SAF Inventory Working Group and University of New Hampshire will be held Nov. 29 thru Dec. 1, 1978 at Durham, NH. The regional workshop designed as an introductory course for forest managers and analysts who need to implement growth and yield methodology in a decision-making role. Enrollment will be limited to 25 on a first-come basis. Registration and fees will be between $50-100. For details contact Dr. James Barrett, INER, James Hall, University of New Hampshire, Durham, NH 03824.

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Get these in your Annual Work Plan for 1979.

July 16-20. Sampling Designs for Successive Inventories. A workshop sponsored by the Colorado State University Dept. of Forest and Wood Sciences and the SAF Inventory Working Group. Registration for this workshop will be $300.

The following week, July 23-27 will be the 1979 Forest Inventory Workshop - sponsored by the SAF and IUFRO, also in Ft. Collins. This will be on the magnitude of the 1978 Tucson and the 1974 Ft. Collins meetings. Make plans now to attend both sessions.

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Tentative plans are being made by Paul Schmid-Haas, the leader of the IUFRO S4.02.3 Working Group on Successive Forest Inventories, for a joint meeting with the Working Group S4.01.02 on Estimation of Increment to be held September 9-15, 1979 in Vienna at the Forsthiche Bundesversuchsanstalt, Schonbrunn-Tirolergarten. The general theme of the meeting is "The growth of single trees and the development of stands as common objects of growth research and inventory". For more details, the reader may get in touch with:

Paul Schmid-Haas
Swiss Forest Research Institute
CH 8903 Birmensdorf
Switzerland

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Wanted! Lead articles, current literature and meeting announcements for publishing in the "Notes". If announcing a meeting, please allow at least a four month lag time.

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